REMARKS

I. Claim Amendment

New Claims 39 - 41 recite selected tempers from those recited by Claim 1.

II. 35 USC §103(a)

Claims 1, 6, 7, 10, 13-16, 18, 19, 23-25, 28, 29, 32 and 35-38 are rejected under 35 USC §103(a) as being unpatentable over Applicant's Admitted Prior Art (AAPA) in view of

Bryans et al. (US 6,973,815),
Park (US 4,589,932) or Ohori et al. (US JP 2001-178704),
Liu et al. (US 5,108,520) and
Chakrabarti et al. (US2002/0150498).

A. Claims 1, 6,7,10, 13, 14, 18, 28, 29 and 32

Claim 1 recites bending a workpiece during cold forming and then artificially aging the bent structure. The present invention's artificial ageing after bending is in addition to other ageing that may have occurred before bending.

The Office Action in the paragraph bridging pages 2 and 3 asserts the alleged AAPA discloses a method for producing an integrated monolithic aluminum structure for a part of a wing skin or frame structure for an aircraft wherein

> an AA7XXX aluminum plate with a thickness in the range of 15 to 70 mm is bent to form a predetermined shape and,
>
> after the bending operation, the plate is machined to produce the monolithic structure,
>
> wherein the aluminum alloy plate has been quenched and stretched (citing paragraph [0043]).

1. The Office action mischaracterized the AAPA

The Office action improperly combined two different mutually exclusive AAPA embodiments mentioned in the patent application into one single AAPA embodiment.

The AAPA discloses different methods of prior art processing.

a. Paragraph [007]

Paragraph [007], discloses a method in which:

the aluminum alloy sheet (previously artificially aged) is bent; and

stringers or beams are attached with rivets or by welding.

Paragraph [009] explains a disadvantage of this method. "Firstly, the plate, which has been produced from an aluminum alloy which has been artificially aged as mentioned above in order to enhance the corrosion resistance, displays considerable distortion after the bending and machining operation thereby showing a vertical and horizontal distortion which makes the assembly of the aircraft fuselage or aircraft wing cumbersome since all parts need additional correction bending and measurement operations."

Also for this method page 8, paragraph [0042] explained, "When the additional components 2 are attached to the base sheet 1 and when the whole structure is finished after the machining and riveting or welding step, a horizontal distortion d_1 and/or vertical distortion d_2 usually results from stress relief from the pre-curved plate or sheet which has been bent before additional components 2 are connected to the base sheet or before components 2 are machined from a plate product with a corresponding thickness." This stress relieving is different from aging. Stress relieving involves heating a product for a short time period at low temperatures. Aging takes longer and is done in a controlled manner to achieve desired strength and corrosion resistance. In particular, artificial aging is performed at higher temperatures than the stress relieving mentioned for this method of the AAPA.

b. Paragraph [008]

Paragraph [008] discloses another method in which:

a plate (previously artificially aged) which has a thickness equal to or greater than the thickness of the sheet constituting the aircraft skin and the height of the stringers or beams is bent; and

after bending the stringers are machined from the plate, thereby milling the aluminum material from between the stringers.

Paragraph [009] explains a disadvantage of this method. "Secondly, the bent and machined structure comprising sheet and stringers or beams displays residual or inner stress originating from such bending operation and resulting in regions or parts of the structure having a microstructure different from other regions with less or more internal residual stress. Those regions with an elevated level of internal residual stress tend to be more considerably susceptible to corrosion and fatigue crack propagation."

c Paragraph [0043]

Paragraph [0043] discloses another method. In contrast, to the method of paragraph [008], the method at page 9, paragraph [0043] does not include bending. As seen in Fig. 3a, the monolithic structure is "shaped" solely by mechanical milling or machining to convert an aluminum alloy block to predetermined shaped structure 5.

d. The improper combination

The Office action has combined two different AAPA's mentioned in the patent to one single AAPA. In particular, the Office action combined different features from the method of paragraph [008] and the method at page 9, paragraph [0043]. It is respectfully submitted this is improper.

In the method of paragraph [008] of the patent specification, mention is made of a known method of producing an aircraft fuselage skin from an aluminum alloy plate having a thickness in the range of 15-70 mm. The plate is bent and, after bending, the stringers are machined from the plate. No mention is made of the type of alloy used in this AAPA, or of the temper of the plate before bending.

In contrast, paragraph [043] of the patent specification relates to a different type of prior art, in which a very thick plate is produced and then directly machined down to obtain a predetermined shaped structure, see Fig. 3a. The word "shaped" in the paragraph is not used in the sense of "bending", paragraph [043] explains the shaping step is a mechanical milling or machining step. Thus, paragraph [043] describes an entirely different type of prior art. It is not proper to combine the method of paragraph [008] and the method of paragraph [0043] into one disclosure.

It is respectfully submitted, of these two AAPA methods, the AAPA of paragraph [008] is more relevant to the present invention because it includes a bending step.

One of the main differences of the invention of Claim 1 over the AAPA of

paragraph [008] is that in the invention the plate is first shaped to a shaped structure having a built-in radius, then the shaped structure is heat-treated by artificial ageing to the second temper and machined to obtain the integrated monolithic aluminum structure. Claim 38 further specifies the machining is after the artificial ageing. The AAPA of paragraph [008] lacks heat-treating by artificial ageing to the second temper.

2. <u>There is no reason to heat treat Bryans' bent material</u>

The Office action also asserts the AAPA does not disclose the bending operation being a cold-forming of a AA7XX aluminum plate that has been brought to a temper selected from the group consisting of T4, T73, T74 and T76 and heat treating by artificially aging said shaped structure to a second temper selected from the group consisting of T6, T79, T78, T77, T76, T74, T73 or T8. However, the Office action asserts Bryans cold forms an aeronautical member from an AA7XXX aluminum alloy plate in a T7451 temper by bending. Thus, it would have been obvious to use in the AAPA an alloy plate in a T7451 temper and bend the aluminum alloy plate in the T7451 temper.

It is respectfully submitted, Bryans teaches away from heat-treating the shaped structure. Bryans, col. 5, lines 3-13 explicitly discloses the material need not be subjected to subsequent heat-treatments.

> In some embodiments, a suitable material for use in the process is a 7000 series aircraft aluminum alloys (*sic*) with a heat treatment of T7451. In some embodiments, the selected material is cold formed, meaning no heat is applied to the material during the process; in some embodiments, the material is formed and processed in a state wherein it was previously heat treated. Further, in the process of the present invention, the selected material need not be subjected to subsequent heat treatments or annealing operations, and the amount of over forming and bending back is may be (*sic*) selected and controlled."

Thus, there is no reason to complicate Bryan's process by inserting heat treatment between Bryans' forming and machining steps. Bryans already has its

material in its desired temper and Bryans et al. teaches machining directly after forming.

Furthermore, Bryans, col. 8, lines 10-17, proposes its own way to manage forming and temper:

> In some embodiments, there will be tensile stress on the outer skin side of the part produced by the process of the present invention, and compressive stresses on the inside integral supporting structure. This may be a result of the forming process and staying within prescribed limits of bend v. plate thickness by alloy and temper (so properties of the selected material are not comprised (*sic, compromised*?)).

Claims 40 and 41 avoid T4 temper to further distinguish over Bryans.

3. <u>Park teaches away from 7XXX alloys</u>

The AAPA of paragraph [008] does not disclose the step of heat-treating to the second temper between shaping and machining.

Bryans does not disclose the step of heat-treating to the second temper between shaping and machining. Thus, to make up for this deficiency in the AAPA and Bryans, the Office action cites Park or Ohori.

It is respectfully submitted it is improper to combine Park with the AAPA as modified to have the AA7XXX alloy of Bryans. Park relates to a completely different alloy, namely an AA6XXX series alloy (see Abstract), and very importantly, to a different use, namely to vehicular members (see column 1, line 10).

Park relates to automotive body parts produced by casting, homogenizing, hot-rolling and cold-rolling to a final gauge much less than 10 mm (see column 5, lines 24-52 and column 8, line 7, where a 0.1 inch thickness is mentioned). This sheet is solution heat treated and quenched. After quenching, the sheet may age naturally until the time the sheet is shaped to its final shape, normally a particular automotive body panel. After shaping, the part can be artificially aged to T6 temper. In particular, Park, col. 6, lines 39-55 discloses "it is generally recognized that a shaping operation can be interposed between solution heat treating and artificial aging operations to advantage

since the moderate strength and higher workability of the T4 temper facilitate such which can be followed by the strength improving operation of artificial aging to produce the T6 type temper."

However, Park only discloses this treatment for 6XXX-series alloys which have quite different properties than the 7XXX series alloys of the present invention. Park even distinguishes the invention over 7XXX-series alloys, see column 14, lines 58-62 "Equally significant is the fact that 7XXX alloys, when substituted for 6061, also include a forming penalty in that 7XXX alloys are more difficult to form and when so shaped exhibit residual stress in the frame." Thus, Park teaches away from subjecting 7XXX alloys to the shaping treatment recommended for 6XXX alloys.

Furthermore, the products of Park are not stretched before bending, as in step a) of claim 1.

Another difference between the AAPA and Park is that the sheets and extrusions of Park are too thin to be machined down. Therefore, the one skilled in the art would not consider this reference.

Finally, Park does not mention aerospace applications at all, but only vehicular and sporting applications such as ski poles and baseball bats (see col. 14, lines 10-25). Generally, the skilled person for aluminum alloys for automotive uses is not the same skilled person as for aerospace uses. Therefore, it is improper to combine Park with the AAPA, even if modified by Bryans, concerning the manufacture of aerospace members.

Claim 41 avoids T6 temper to further distinguish over the AAPA, even if combined with Bryans and Park.

4. Ohori teaches away from 7XXX alloys

As an alternative to Park, the Office action cites Ohori (JP 2000178704). However, this reference concerns extruded products of a 6000-series alloy. In contrast, the present invention relates to AA 7XXX series alloy.

AA 7XXX series alloys differ from AA 6XXX series alloys. The alloy designation in the 2XXX through 8XXX groups is determined by the alloying element (Mg_2Si for 6XXX alloys) present in the greatest mean percentage (ATTACHMENT I, International

Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys, The Aluminum Association, p. 18 (January 2001). In contrast, zinc, in amounts of 1 to 8 %, is the major alloying element in AA 7XXX series alloy (See p. 59 of ATTACHMENT II, ASM Specialty Handbook, Aluminum and Aluminum Alloys, J. Davis, ed., ASM International (1993)).

Also, as mentioned above, Ohori concerns extruded products. Therefore, it is evidently improper to combine this reference with the AAPA even if modified by Bryans, because a plate product according to the invention cannot be produced by extrusion.

Furthermore, Ohori relates to extrusions for motor vehicles, while the invention is concerned with aerospace products.

The Office action asserts Ohori teaches a double heat-treatment of ageing aluminum alloy before and after bending. However, the abstract available from esp@cenet-Bibiligraphic Data of the European Patent Office states the extruded shape is first aged to T1, and after bending aged to T2 condition (ATTACHMENT III, esp@cenet-Bibiligraphic Data for JP 2000178704). T1 and T2 are quite different temper conditions than T4 and T6 and T7 and essentially cannot be compared (See p.p. 29-30 of ATTACHMENT III, ASM Specialty Handbook, Aluminum and Aluminum Alloys, J. Davis, ed., ASM International (1993)).

T1 applies to product cooled from an elevated-temperature shaping process and naturally aged to a substantially stable condition. T2 applies to a product cooled from an elevated-temperature shaping process, cold-worked and naturally aged to a substantially stable condition. (ATTACHMENT II, p.p. 29-30).

T4 applies to product that has been solution heat treated and naturally aged to a substantially stable condition. T6 applies to product that has been solution heat-treated and artificially aged. T7 applies to product that has been solution heat-treated and over aged or stabilized. (ATTACHMENT II, p.p. 29-30).

5. Liu et al. and Chakrabarti et al.

Page 4 of the Office action cited Liu et al. for composition of 7xxx-series of aluminum alloys. Chakrabarti et al. at page 4 of the Office action was cited for

disclosing properties of various tempers.

It is submitted neither of these references makes up for the above-discussed deficiencies of the combination of AAPA, Bryans et al and Park or Ohori.

B. Claims 15-16, 19 and 23-25

These claims further distinguish the present invention over the references.

C. Claims 35-37

Claims 35-37 further distinguish over the references as they recite the method of manufacturing various structural parts of an aircraft.

D. Claim 38

Claim 38 further distinguishes over the references by reciting machining after artificial ageing.

E. Claims 39-41

Claim 39-41 further distinguish over the references by reciting selected tempers.

III. Conclusion

In view of the above it is respectfully submitted that all objections and rejections are overcome. Thus, a Notice of Allowance is respectfully requested.

Respectfully submitted,

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ATTACHMENT I, International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys, The Aluminum Association, p. 18 (January 2001)

REGISTRATION RECORD SERIES

International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys

Unified North American and International Registration Records

The Aluminum Association
Incorporated
900 19th Street, N.W., Washington, D.C. 20006

Revised: January 2001

Supersedes: July 1998

RECOMMENDATION

INTERNATIONAL DESIGNATION SYSTEM FOR WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS

This Recommendation is based on the numerical designation system for wrought aluminum and wrought aluminum alloys which was adopted in the U.S.A. in 1954, and became its national standard in 1957. This Recommendation was officially adopted by the International Signatories of the Declaration of Accord on December 15, 1970 and was editorially revised on May 1, 1974.

Designations in accordance with this Recommendation may be used by any country, but there is no obligation to use them. For use, see Appendixes A and B.

A numerical designation assigned in conformance with this Recommendation should only be used to indicate an aluminum or an aluminum alloy having chemical composition limits identical to those registered with the Signatories to the Declaration of Accord on an International Alloy Designation System for Wrought Aluminum and Wrought Aluminum Alloys.

1. Scope

This recommendation describes a four-digit numerical system for designating wrought aluminum and wrought aluminum alloys.

2. Alloy Groups

The first of the four digits in the designation indicates the alloy group as follows:

Aluminum, 99.00 percent and greater	1xxx
Aluminum alloys grouped by major alloying elements[1,2,3]	
Copper	2xxx
Manganese	3xxx
Silicon	4xxx
Magnesium	5xxx
Magnesium and Silicon	6xxx
Zinc	7xxx
Other elements	8xxx
Unused series	9xxx

3. 1xxx Group

The designation assigned shall be in the 1xxx group whenever the minimum aluminum content is specified as 99.00 percent and greater. In the 1xxx group, the last two of the four digits in the designation indicate the minimum aluminum percentage[4]. These digits are the same as the two digits to the right of the decimal point in minimum aluminum percentage when it is expressed to the nearest 0.01 percent. The second digit in the alloy designation indicates alloy modifications in impurity limits or alloying elements. If the second digit in the designation is zero, it indicates unalloyed aluminum having natural impurity limits; integers 1 through 9, which are assigned consecutively as needed, indicate special control of one or more individual impurities or alloying elements.

4. 2xxx-8xxx Groups

The alloy designation in the 2xxx through 8xxx groups is determined by the alloying element (Mg_2Si for 6xxx alloys) present in the greatest mean percentage. If the greatest mean percentage is common to more than one alloying element, choice of group will be in order of group sequence Cu, Mn, Si, Mg, Mg_2Si, Zn or Others. In the 2xxx through 8xxx alloy groups the last two of the four digits in the designation have no special significance but serve only to identify the different aluminum alloys in the group. The second digit in the alloy designation indicates the original alloy[5] and alloy modifications. Integers 1 through 9, which are assigned consecutively, indicate alloy modifications.

5. Modifications

A modification of the original alloy[5] is limited to any one or a combination of the following:

(a) Change of not more than the following amounts in the arithmetic mean of the limits for an individual alloying element or combination of elements expressed as an alloying element or both:

Arithmetic Mean of Limits for Alloying Elements in Original Alloy	Maximum Change
Up through 1.0 percent	0.15
Over 1.0 through 2.0 percent	0.20
Over 2.0 through 3.0 percent	0.25
Over 3.0 through 4.0 percent	0.30
Over 4.0 through 5.0 percent	0.35
Over 5.0 through 6.0 percent	0.40
Over 6.0 percent	0.50

See footnotes on page 19

To determine compliance when maximum and minimum limits are specified for a combination of two or more elements in one alloy composition, the mean of such combination should be compared to the sum of the mean values of the same individual elements, or any combination thereof, in another alloy composition.

(b) Addition or deletion of not more than one alloying element with limits having an arithmetic mean of not more than 0.30 percent, or addition or deletion of not more than one combination of elements expressed as an alloying element with limits having a combined arithmetic mean of not more than 0.40 percent.

(c) Substitution of one alloying element for another element serving the same purpose.

(d) Change in limits for impurities expressed singly or as a combination.

(e) Change in limits for grain refining elements.

(f) Maximum iron or silicon limits of 0.12 percent and 0.10 percent, or less, respectively, reflecting high purity base metal.

An alloy should not be registered as a modification if it meets the requirements for a national variation.

6. National Variations

National variations of wrought aluminum and wrought aluminum alloys registered by another country in accordance with this Recommendation are identified by a serial letter after the numerical designation. The serial letters are assigned in alphabetical sequence starting with A for the first national variation registered, but omitting I, O, and Q.

A national variation has composition limits which are similar but not identical to those registered by another country, with differences such as:

(a) Differences in arithmetic mean of limits for an individual alloying element or combination of elements expressed as an alloying element, or both, not exceeding the following amounts:

Arithmetic Mean of Limits for Alloying Elements in Original Alloy or Modification	Maximum Difference
Up through 1.0 percent	0.15
Over 1.0 through 2.0 percent	0.20
Over 2.0 through 3.0 percent	0.25
Over 3.0 through 4.0 percent	0.30
Over 4.0 through 5.0 percent	0.35
Over 5.0 through 6.0 percent	0.40
Over 6.0 percent	0.50

To determine compliance when maximum and minimum limits are specified for a combination of two or more elements in one alloy composition, the mean of such combination should be compared to the sum of the mean values of the same individual elements, or any combination thereof, in another alloy composition.

(b) Substitution of one alloying element for another element serving the same purpose.

(c) Different limits of impurities except for low iron. Iron maximum of 0.12 percent or less, reflecting high purity base metal, should be considered an alloy modification. See 5(f).

(d) Different limits on grain refining elements.

(e) Inclusion of a minimum limit for iron or silicon, or both.

An alloy meeting these requirements should not be registered as a new alloy or alloy modification.

ATTACHMENT II - ASM Specialty Handbook, Aluminum and Aluminum Alloys, J. Davis, ed., p.p. 29-30 and 59-62, ASM International (1993))

Aluminum and Aluminum Alloys

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temper designations have already been assigned for wrought products in all alloys:

- *Hx11* applies to products that incur sufficient strain hardening after final annealing to fail to qualify as O temper, but not so much or so consistent an amount of strain hardening to qualify as Hx1 temper.
- *H112* pertains to products that may acquire some strain hardening during working at elevated temperature and for which there are mechanical property limits.
- *Patterned or Embossed Sheet.* Table 5 lists the three-digit H temper designations that have been assigned to patterned or embossed sheet.

System for Heat-Treatable Alloys

The temper designation system for wrought and cast products that are strengthened by heat treatment employs the W and T designations described in the section "Basic Temper Designations" in this article. The W designation denotes an unstable temper, whereas the T designation denotes a stable temper other than F, O, or H. The T is followed by a numeral from 1 to 10, each numeral indicating a specific sequence of basic treatments. A description of how aluminum alloys are classified as heat-treatable versus non-heat-treatable can be found in the article "General Introduction" in this volume.

T1, Cooled from an Elevated-Temperature Shaping Process and Naturally Aged to a Substantially Stable Condition. This designation applies to products that are not cold-worked after an elevated-temperature shaping process such as casting or extrusion and for which mechanical properties have been stabilized by room-temperature aging. It also applies to products that are flattened or straightened after cooling from the shaping process, for which the effects of the cold work imparted by flattening or straightening are not accounted for in specific property limits.

T2, Cooled from an Elevated-Temperature Shaping Process, Cold-Worked, and Naturally Aged to a Substantially Stable Condition. This variation refers to products that are cold-worked specifically to improved strength after cooling from a hot-working process such as rolling or extrusion and for which mechanical properties have been stabilized by room-temperature aging. It also applies to products in which the effects of cold work, imparted by flattening or straightening, are accounted for in specified property limits.

T3, Solution Heat-Treated, Cold-Worked, and Naturally Aged to a Substantially Stable Condition. T3 applies to products that are cold-worked specifically to improve strength after solution heat treatment and for which mechanical properties have been stabilized by room-temperature aging. It also applies to products in which the effects of cold work, imparted by flattening or straightening, are accounted for in specified property limits.

T4, Solution Heat-Treated and Naturally Aged to a Substantially Stable Condition. This signifies products that are not cold-worked after solution heat treatment and for which mechanical properties have been stabilized by room-temperature aging. If the products are flattened or straightened, the effects of the cold work imparted by flattening or straightening are not accounted for in specified property limits.

T5, Cooled from an Elevated-Temperature Shaping Process and Artificially Aged. T5 includes products that are not cold-worked after an elevated-temperature shaping process such as casting or extrusion and for which mechanical properties have been substantially improved by precipitation heat treatment. If the products are flattened or straightened after cooling from the shaping process, the effects of the cold work imparted by flattening or straightening are not accounted for in specified property limits.

T6, Solution Heat-Treated and Artificially Aged. This group encompasses products that are not cold-worked after solution heat treatment and for which mechanical properties or dimensional stability, or both, have been substantially improved by precipitation heat treatment. If the products are flattened or straightened, the

Table 4 ISO equivalents of wrought Aluminum Association international alloy designations

Aluminum Association international designation	ISO designation	Aluminum Association international designation	ISO designation
1050A	Al 99.5	5086	Al Mg4
1060	Al 99.6	5154	Al Mg3.5
1070A	Al 99.7	5154A	Al Mg3.5(A)
1080A	Al 99.8	5183	Al Mg4.5Mn0.7(A)
1100	Al 99.0 Cu	5251	Al Mg2
1200	Al 99.0	5356	Al Mg5Cr(A)
1350	E-Al 99.5	5454	Al Mg3Mn
[illegible]	Al 99.5	5456	Al Mg5Mn
1370	E-Al 99.7	5554	Al Mg3Mn(A)
2011	Al Cu6BiPb	5754	Al Mg3
2014	Al Cu4SiMg	6005	Al SiMg
2014A	Al Cu4SiMg(A)	6005A	Al SiMg(A)
2017	Al Cu4MgSi	6060	Al MgSi
2017A	Al Cu4MgSi(A)	6061	Al Mg1SiCu
2024	Al Cu4Mg1	6063	Al Mg0.7Si
2030	Al Cu4PbMg	6063A	Al Mg0.7Si(A)
2117	Al Cu2.5Mg	6082	Al Si1MgMn
2219	Al Cu6Mn	6101	E-Al MgSi
3003	Al Mn1Cu	6101A	E-Al MgSi(A)
3004	Al Mn1Mg1	6181	Al Si1Mg0.8
3005	Al Mn1Mg0.5	6262	Al Mg1SiPb
3103	Al Mn1	6351	Al Si1Mg0.5Mn
3105	Al Mn0.5Mg0.5	7005	Al Zn4.5Mg1.5Mn
4043	Al Si5	7010	Al Zn6MgCu
4043A	Al Si5(A)	7020	Al Zn4.5Mg1
4047	Al Si12	7049A	Al Zn8MgCu
4047A	Al Si12(A)	7050	Al Zn6CuMgZr
5005	Al Mg1(B)	7075	Al Zn5.5MgCu
5050	Al Mg1.5(C)	7178	Al Zn7MgCu
5052	Al Mg2.5	7475	Al Zn5.5MgCu(A)
5056	Al Mg5Cr	[illegible]	Al Zn4Mg1.5Mn
5056A	Al Mg5	[illegible]	Al Zn6MgCuMn
5083	Al Mg4.5Mn0.7		

Table 5 H temper designations for aluminum and aluminum alloy patterned or embossed sheet

Patterned or embossed sheet	Temper of sheet from which textured sheet was fabricated
H114	O
H124	H11
H224	H21
H324	H31
H134	H12
H234	H22
H334	H32
H144	H13
H244	H23
H344	H33
H154	H14
H254	H24
H354	H34
H164	H15
H264	H25
H364	H35
H174	H16
H274	H26
H374	H36
H184	H17
H284	H27
H384	H37
H194	H18
H294	H28
H394	H38
H195	H19
H295	H29
H395	H39

Source: Ref 7

ATTACHMENT II - ASM Specialty Handbook, Aluminum and Aluminum Alloys, J. Davis, ed., p.p. 29-30 and 59-62, ASM International (1993))

effects of the cold work imparted by flattening or straightening are not accounted for in specified property limits.

T7, Solution Heat-Treated and Overaged or Stabilized. T7 applies to wrought products that have been precipitation heat-treated beyond the point of maximum strength to provide some special characteristic, such as enhanced resistance to stress-corrosion cracking or exfoliation corrosion (both of these modes of corrosion are described in the article "Corrosion Behavior" in this Volume). It applies to cast products that are artificially aged after solution heat treatment to provide dimensional and strength stability.

T8, Solution Heat-Treated, Cold-Worked, and Artificially Aged. This designation applies to products that are cold-worked specifically to improve strength after solution heat treatment and for which mechanical properties or dimensional stability, or both, have been substantially improved by precipitation heat treatment. The effects of cold work, including any cold work imparted by flattening or straightening, are accounted for in specified property limits.

T9, Solution Heat-Treated, Artificially Aged, and Cold-Worked. This grouping is comprised of products that are cold-worked specifically to improve strength after they have been precipitation heat-treated.

T10, Cooled from an Elevated-Temperature Shaping Process, Cold-Worked, and Artificially Aged. T10 identifies products that are cold-worked specifically to improve strength after cooling from a hot-working process such as rolling or extrusion and for which mechanical properties have been substantially improved by precipitation heat treatment. The effects of cold work, including any cold work imparted by flattening or straightening, are accounted for in specified property limits.

Additional T Temper Variations. When it is desirable to identify a variation of one of the ten major T tempers described above, additional digits, the first of which cannot be zero, may be added to the designation.

Specific sets of additional digits have been assigned to stress-relieved wrought products:

Stress-Relieved by Stretching, Compressing, or Combination of Stretching and Compressing. This designation applies to the following products when stretched to the indicated amounts after solution heat treatment or after cooling from an elevated-temperature shaping process:

Product form	Permanent set, %
Plate	1½-3
Rod, bar, shapes, and extruded tube	1-3
Drawn tube	½-3

- Tx51 applies specifically to plate, to rolled or cold-finished rod and bar, to die or ring forgings, and to rolled rings. These products receive no further straightening after stretching.
- Tx510 applies to extruded rod, bar, shapes and tubing, and to drawn tubing. Products in this temper receive no further straightening after stretching.
- Tx511 refers to products that may receive minor straightening after stretching to comply with standard tolerances.

One variation involves stress relief by compressing:

- Tx52 applies to products that are stress-relieved by compressing after solution heat treatment or after cooling from a hot-working process to produce a permanent set of 1 to 5%.

The next designation is used for products that are stress-relieved by combining stretching and compressing:

- Tx54 applies to die forgings that are stress-relieved by restriking cold in the finish die. (These same digits—and 51, 52, and 54—may be added to the designation W to indicate unstable solution heat-treated and stress-relieved tempers.)

Temper designations have been assigned to wrought products heat-treated from the O or the F temper to demonstrate response to heat treatment:

- T42 means solution heat-treated from the O or the F temper to demonstrate response to heat treatment and naturally aged to a substantially stable condition.
- T62 means solution heat-treated from the O or the F temper to demonstrate response to heat treatment and artificially aged.

Temper designations T42 and T62 also may be applied to wrought products heat-treated from any temper by the user when such heat treatment results in the mechanical properties applicable to these tempers.

System for Annealed Products

A digit following the O indicated a product in annealed condition having special characteristics. For example, for heat-treatable alloys, O1 indicates a product that has been heat-treated at approximately the same time and temperature required for solution heat treatment and then air-cooled to room temperature; this designation applies to products that are to be machined prior to solution heat treatment by the user. Mechanical property limits are not applicable.

Designation of Unregistered Tempers

The letter P has been assigned to denote H, T, and O temper variations that are negotiated between manufacturer and purchaser. The letter P follows the temper designation that most nearly pertains. The use of this type of designation includes situations where:

- The use of the temper is sufficiently limited to preclude its registration.
- The test conditions are different from those required for registration with the Aluminum Association.
- The mechanical property limits are not established on the same basis as required for registration with the Aluminum Association.

Foreign Temper Designations

Unlike the agreement relating to wrought alloy designations, there is no Declaration of Accord for an international system of tempers to be registered with the Aluminum Association by foreign organizations. For the most part, the ANSI system is used, but because there is no international accord, reference to ANSI H35.1 properties and characteristics of aluminum alloy tempers registered with the Aluminum Association under ANSI 35.1 may not always reflect actual properties and characteristics associated with the particular alloy temper. In addition, temper designations may be created that are not registered with the Aluminum Association.

ACKNOWLEDGMENT

The information in this article is largely taken from R.B.C. Cayless, Alloy and Temper Designation Systems for Aluminum and Aluminum Alloys, Volume 2 of the *ASM Handbook* (formerly *Metals Handbook*, 10th Edition), ASM International, 1990, p 15-28.

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ATTACHMENT II - ASM Specialty Handbook, Aluminum and Aluminum Alloys, J. Davis, ed., p.p. 29-30 and 59-62, ASM International (1993))

Wrought Products

ALUMINUM wrought products are those aluminum products that have been subjected to plastic deformation by hot working and cold working processes (such as rolling, extruding, and drawing, either singly or in combination), so as to transform cast aluminum ingot into desired product form.

The microstructural changes associated with the working and with any accompanying thermal treatments are used to control certain properties and characteristics of the worked, or wrought, product or alloy.

Typical examples of wrought products include plate or sheet (which is subsequently formed or machined into products such as aircraft or building components), household foil, extruded shapes such as storm window frames, and forged automotive and airframe components. A vast difference in the mechanical and physical properties of aluminum wrought products can be obtained through the control of the chemistry, processing, and thermal treatment.

General Characteristics of Wrought Alloys

Aluminum alloys are commonly grouped into an alloy designation series, as described in the article "Alloy and Temper Designation Systems" in this Volume. The general characteristics of the alloy groups are described below, and the comparative corrosion and fabrication characteristics and some typical applications of the commonly used grades or alloys in each group are presented in Table 1.

1xxx Series. Aluminum of 99.00% or higher purity has many applications, especially in the electrical and chemical fields. These grades of aluminum are characterized by excellent corrosion resistance, high thermal and electrical conductivities, low mechanical properties, and excellent workability. Moderate increases in strength may be obtained by strain hardening. Iron and silicon are the major impurities. Typical uses include chemical equipment, reflectors, heat exchangers, electrical conductors and capacitors, packaging foil, architectural applications, and decorative trim.

2xxx Series. Copper is the principal alloying element in 2xxx series alloys, often with magnesium as a secondary addition. These alloys require solution heat treatment to obtain optimum properties; in the solution heat-treated condition, mechanical properties are similar to, and sometimes exceed, those of low-carbon steel. In some instances, precipitation heat treatment (aging) is employed to further increase mechanical properties. This treatment increases yield strength, with attendant loss in elongation; its effect on tensile strength is not as great.

The alloys in the 2xxx series do not have corrosion resistance as good as that of most other aluminum alloys, and under certain conditions they may be subject to intergranular corrosion. Therefore, these alloys in the form of sheet usually are clad with a high-purity aluminum or with a magnesium-silicon alloy of the 6xxx series, which provides galvanic protection of the core material and thus greatly increases resistance to corrosion.

Alloys in the 2xxx series are particularly well suited for parts and structures requiring high strength-to-weight ratios and are commonly used to make truck and aircraft wheels, truck suspension parts, aircraft fuselage and wing skins, and structural parts and those parts requiring good strength at temperatures up to 150 °C (300 °F). Except for alloy 2219, these alloys have limited weldability, but some alloys in this series have superior machinability.

3xxx Series. Manganese is the major alloying element of 3xxx series alloys. These alloys generally are non-heat-treatable but have about 20% more strength than 1xxx series alloys. Because only a limited percentage of manganese (up to about 1.5%) can be effectively added to aluminum, manganese is used as a major element in only a few alloys. However, three of them—3003, 3004, and 3105—are widely used as general-purpose alloys for moderate-strength applications requiring good workability. These applications include beverage cans, cooking utensils, heat exchangers, storage tanks, awnings, furniture, highway signs, roofing, siding, and other architectural applications.

4xxx Series. The major alloying element in 4xxx series alloys is silicon, which can be added in sufficient quantities (up to 12%) to cause substantial lowering of the melting range without producing brittleness. For this reason, aluminum-silicon alloys are used in welding wire and as brazing alloys for joining aluminum, where a lower melting range than that of the base metal is required. Most alloys in this series are non-heat-treatable, but when used in welding heat-treatable alloys, they will pick up some of the alloying constituents of the latter and so respond to heat treatment to a limited extent. The alloys containing appreciable amounts of silicon become dark gray to charcoal when anodic oxide finishes are applied and hence are in demand for architectural applications. Alloy 4032 has a low wear resistance, and thus it is well suited to production of forged engine pistons.

5xxx Series. The major alloying element in 5xxx series alloys is magnesium. When it is used as a major alloying element or with manganese, the result is a moderate-to-high-strength work-hardenable alloy. Magnesium is considerably more effective than manganese as a hardener, about 0.8% Mg being equal to 1.25% Mn, and it can be added in considerably higher quantities. Alloys in this series possess good welding characteristics and good resistance to corrosion in marine atmospheres. However, certain limitations should be placed on the amount of cold work and the safe operating temperatures permissible for the higher-magnesium alloys (over about 3.5% for operating temperatures above about 65 °C, or 150 °F) to avoid susceptibility to stress-corrosion cracking.

Uses include architectural, ornamental, and decorative trim; cans and can ends; household appliances; streetlight standards; boats and ships, cryogenic tanks; crane parts; and automotive structures.

6xxx Series. Alloys in the 6xxx series contain silicon and magnesium approximately in the proportions required for formation of magnesium silicide (Mg_2Si), thus making them heat-treatable. Although not as strong as most 2xxx and 7xxx alloys, 6xxx series alloys have good formability, weldability, machinability, and corrosion resistance, with medium strength. Alloys in this heat-treatable group may be formed in the T4 temper (solution heat-treated but not precipitation heat-treated) and strengthened after forming to full T6 properties by precipitation heat treatment. Uses include architectural applications, bicycle frames, transportation equipment, bridge railings, and welded structures.

7xxx Series. Zinc, in amounts of 1 to 8%, is the major alloying element in 7xxx series alloys, and when coupled with a smaller percentage of magnesium it results in heat-treatable alloys of moderate to very high strength. Usually other elements, such as copper and chromium, are also added in small quantities. 7xxx series alloys are

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Table 1 Comparative corrosion and fabrication characteristics and typical applications of wrought aluminum alloys

Alloy temper	Resistance to corrosion: General(a)	Resistance to corrosion: Stress-corrosion cracking(b)	Workability (cold)(e)	Machinability(e)	Weldability(f): Gas	Weldability(f): Arc	Weldability(f): Resistance spot and seam	Brazeability(f)	Solderability(g)	Some typical applications of alloys
1050-0	A	A	A	E	A	A	B	A	A	Chemical equipment, railroad tank cars
H12	A	A	A	E	A	A	A	A	A	
H14	A	A	A	D	A	A	A	A	A	
H16	A	A	B	D	A	A	A	A	A	
H18	A	A	B	D	A	A	A	A	A	
1060-0	A	A	A	E	A	A	B	A	A	Chemical equipment, railroad tank cars
H12	A	A	A	E	A	A	A	A	A	
H14	A	A	A	D	A	A	A	A	A	
H16	A	A	B	D	A	A	A	A	A	
H18	A	A	B	D	A	A	A	A	A	
1100-0	A	A	A	E	A	A	B	A	A	Sheet-metal work, spun hollowware, fin stock
H12	A	A	A	E	A	A	A	A	A	
H14	A	A	A	D	A	A	A	A	A	
H16	A	A	B	D	A	A	A	A	A	
H18	A	A	C	D	A	A	A	A	A	
1145-0	A	A	A	E	A	A	B	A	A	Foil, fin stock
H12	A	A	A	E	A	A	A	A	A	
H14	A	A	A	D	A	A	A	A	A	
H16	A	A	B	D	A	A	A	A	A	
H18	A	A	B	D	A	A	A	A	A	
1199-0	A	A	A	E	A	A	B	A	A	Electrolytic capacitor foil, chemical equipment, railroad tank cars
H12	A	A	A	E	A	A	A	A	A	
H14	A	A	A	D	A	A	A	A	A	
H16	A	A	B	D	A	A	A	A	A	
H18	A	A	B	D	A	A	A	A	A	
1350-0	A	A	A	E	A	A	B	A	A	Electrical conductors
H12, H111	A	A	A	E	A	A	A	A	A	
H14, H24	A	A	A	D	A	A	A	A	A	
H16, H26	A	A	B	D	A	A	A	A	A	
H18	A	A	B	D	A	A	A	A	A	
2011 T3	D(c)	D	C	A	D	D	D	D	C	Screw-machine products
T4, T451	D(c)	D	B	A	D	D	D	D	C	
T8	D	B	D	A	D	D	D	D	C	
2014-0	...	...	...	D	D	D	B	D	C	Truck frames, aircraft structures
T3, T4, T451	D(c)	C	C	B	D	B	B	D	C	
T6, T651, T6510, T6511	D	C	D	B	D	B	B	D	C	
2024-0	...	...		D	D	D	D	D	C	Truck wheels, screw-machine products, aircraft structures
T4, T3, T351, T3510, T3511	D(c)	C	C	B	C	B	B	D	C	
T361	D(c)	C	D	B	D	C	B	D	C	
T6	D	B	C	B	D	C	B	D	C	
T861, T81, T851, T8510, T8511	D	B	D	B	D	C	B	D	C	
T72	...	...	...	B	...	...	...	...	...	
2036 T4	C	...	B	C	...	B	B	D	...	Auto-body panel sheet
2124 T851	D	B	D	B	D	C	B	D	C	Military supersonic aircraft
2218 T61	D	C	...		...	...	C	...	C	Jet engine impellers and rings
T72	D	C	...	B	D	C	B	D	C	
2219-0	...	...	...	...	D	A	B	D		Structural uses at high temperatures (to 315 °C, or 600 °F) high-strength weldments
T31, T351, T3510, T3511	D(c)	C	C	B	A	A	A	D	NA	
T37	D(c)	C	D	B	A	A	A	D		
T81, T851, T8510, T8511	D	B	D	B	A	A	A	D		
T87	D	B	D	B	A	A	A	D		
2618 T61	D	C	...	B	D	C	B	D	NA	Aircraft engines
3003-0	A	A	A	E	A	A	B	A	A	Cooking utensils, chemical equipment, pressure vessels, sheet-metal work, builder's hardware, storage tanks
H12	A	A	A	E	A	A	A	A	A	
H14	A	A	B	D	A	A	A	A	A	
H16	A	A	C	D	A	A	A	A	A	
H18	A	A	C	D	A	A	A	A	A	
H25	A	A	B	D	A	A	A	A	A	
3004-0	A	A	A	D	B	A	B	B	B	Sheet-metal work, storage tanks
H32	A	A	B	D	B	A	A	B	B	
H34	A	A	B	C	B	A	A	B	B	
H36	A	A	C	C	B	A	A	B	B	
H38	A	A	C	C	B	A	A	B	B	
3105-0	A	A	A	E	B	A	B	B	B	Residential siding, mobile homes, rain-carrying goods, sheet-metal work
H12	A	A	B	E	B	A	A	B	B	
H14	A	A	B	D	B	A	A	B	B	
H16	A	A	C	D	B	A	A	B	B	
H18	A	A	C	D	B	A	A	B	B	

(continued)

(a) Ratings A through E are relative ratings in decreasing order of merit, based on exposures to sodium chloride solution by intermittent spraying or immersion. Alloys with A and B ratings can be used in industrial and seacoast atmospheres without protection. Alloys with C, D, and E ratings generally should be protected at least on faying surfaces. (b) Stress-corrosion cracking ratings are based on service experience and on laboratory tests of specimens exposed to the 3.5% sodium chloride alternate immersion test. A = No known instance of failure in service or in laboratory tests. B = No known instance of failure in service; limited failures in laboratory tests of short transverse specimens. C = Service failures with sustained tension stress acting in short transverse direction relative to grain structure; limited failures in laboratory tests of long transverse specimens. D = Limited service failures with sustained longitudinal or long transverse stress. (c) In relatively thick sections the rating would be E. (d) This rating may be different for material held at elevated temperature for long periods. (e) Ratings A through D for workability (cold), and A through E for machinability, are relative ratings in decreasing order of merit. (f) Ratings A through D for weldability and brazeability are relative ratings defined as follows: A = Generally weldable by all commercial procedures and methods. B = Weldable with special technique or for specific applications; requires preliminary trials or testing to develop welding procedure and weld performance. C = Limited weldability because of crack sensitivity or loss in resistance to corrosion and mechanical properties. D = No commonly used welding methods have been developed. (g) Ratings A through D and NA for solderability are relative ratings defined as follows: A = Excellent. B = Good. C = Fair. D = Poor. NA = Not applicable.

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Table 1 (continued)

Alloy temper	Resistance to corrosion: General(a)	Resistance to corrosion: Stress-corrosion cracking(b)	Workability (cold)(e)	Machinability(e)	Weldability(f): Gas	Weldability(f): Arc	Weldability(f): Resistance spot and seam	Brazeability(f)	Solderability(g)	Some typical applications of alloys
H25	A	A	B	D	B	A	A	B	B	
4032 T6	C	B	...	B	D	B	C	D	NA	Pistons
4043	B	A	NA	C	NA	NA	NA	NA	NA	Welding electrode
5005 O	A	A	A	E	A	A	B	B	B	Appliances, utensils, architectural, electrical conductors
H12	A	A	A	E	A	A	A	B	B	
H14	A	A	B	D	A	A	A	B	B	
H16	A	A	C	D	A	A	A	B	B	
H18	A	A	C	D	A	A	A	B	B	
H32	A	A	B	E	A	A	A	B	B	
H34	A	A	C	D	A	A	A	B	B	
H36	A	A	C	D	A	A	A	B	B	
H38	A	A		D	A	A	A	B	B	
5050 O	A	A	A	E	A	A	B	B	C	Builders' hardware, refrigerator trim, coiled tubes
H32	A	A	A	D	A	A	A	B	C	
H34	A	A	B	D	A	A	A	B	C	
H36	A	A	C	C	A	A	A	B	C	
H38	A	A	C	C	A	A	A	B	C	
5052 O	A	A	A	D	A	A	B	C	D	Sheet-metal work, hydraulic tube, appliances
H32	A	A	B	D	A	A	A	C	D	
H34	A	A	B	C	A	A	A	C	D	
H36	A	A	C	C	A	A	A	C	D	
H38	A	A	C	C	A	A	A	C	D	
5056 O	A(d)	B(d)	A	D	C	A	B	D	D	Cable sheathing, rivets for magnesium, screen wire, zippers
H111	A(d)	B(d)	A	D	C	A	A	D	D	
H12, H32	A(d)	B(d)	B	D	C	A	A	D	D	
H14, H34	A(d)	B(d)	B	C	C	A	A	D	D	
H18, H38	A(d)	C(d)	C	C	C	A	A	D	D	
H192	B(d)	D(d)	D	B	C	A	A	D	D	
H392	B(d)	D(d)	D	B	C	A	A	D	D	
5083 O	A(d)	A(d)	B	D	C	A	B	D	D	Unfired, welded pressure vessels, marine, auto aircraft cryogenics, TV towers, drilling rigs, transportation equipment, missile components
H321, H116	A(d)	A(d)	C	D	C	A	A	D	D	
H111	A(d)	B(d)	C	D	C	A	A	D	D	
5086 O	A(d)	A(d)	A	D	C	A	B	D	D	
H32, H116	A(d)	A(d)	B	D	C	A	A	D	D	
H34	A(d)	B(d)	B	C	C	A	A	D	D	
H36	A(d)	B(d)	C	C	C	A	A	D	D	
H38	A(d)	B(d)	C	C	C	A	A	D	D	
H111	A(d)	A(d)	B	D	C	A	A	D	D	
5154 O	A(d)	A(d)	A	D	C	A	B	D	D	Welded structures, storage tanks, pressure vessels, salt-water service
H32	A(d)	A(d)	B	D	C	A	A	D	D	
H34	A(d)	A(d)	B	C	C	A	A	D	D	
H36	A(d)	A(d)	C	C	C	A	A	D	D	
H38	A(d)	A(d)	C	C	C	A	A	D	D	
5182 O	A	A(d)	A	D	C	A	B	D	D	Automobile body sheet, can ends
H19	A	A(d)	D	B	C	A	A	D	D	
5252 H24	A	A	B	D	A	A	A	C	D	Automotive and appliance trim
H25	A	A	B	C	A	A	A	C	D	
H28	A	A	C	C	A	A	A	C	D	
5254 O	A(d)	A(d)	A	D	C	A	B	D	D	Hydrogen peroxide and chemical storage vessels
H32	A(d)	A(d)	B	D	C	A	A	D	D	
H34	A(d)	A(d)	B	C	C	A	A	D	D	
H36	A(d)	A(d)	C	C	C	A	A	D	D	
H38	A(d)	A(d)	C	C	C	A	A	D	D	
5356	A	A	NA	B	NA	NA	NA	NA	NA	Welding electrode
5454 O	A	A	A	D	C	A	B	D		Welded structures, pressure vessels, marine service
H32	A	A	B	D	C	A	A	D		
H34	A	A	B	C	C	A	A	D	NA	
H111	A	A	B	D	C	A	A	D		
5456 O	A(d)	B(d)	B	D	C	A	B	D		High-strength welded structures, storage tanks, pressure vessels, marine applications
H111	A(d)	B(d)	C	D	C	A	A	D		
H321, H116	A(d)	B(d)	C	D	C	A	A	D	NA	
5457 O	A	A	A	E	A	A	B	B	B	
5652 O	A	A	A	D	A	A	B	C	D	Hydrogen peroxide and chemical storage vessels
H32	A	A	B	D	A	A	A	C	D	
H34	A	A	B	C	A	A	A	C	D	
H36	A	A	C	C	A	A	A	C	D	
H38	A	A	C	C	A	A	A	C	D	
5657 H241	A	A	A	D	A	A	A	B		Anodized auto and appliance trim

(continued)

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Table 1 (continued)

Alloy temper	Resistance to corrosion: General(a)	Resistance to corrosion: Stress-corrosion cracking(b)	Workability (cold)(e)	Machinability(e)	Weldability(f): Gas	Weldability(f): Arc	Weldability(f): Resistance spot and seam	Brazeability(f)	Solderability(g)	Some typical applications of alloys
H25	A	A	B	D	A	A	A	B	NA	
H26	A	A	B	D	A	A	A	B		
H28	A	A	C	D	A	A	A	B		
6005 T5	B	A	C	C	A	A	A	A	NA	Heavy-duty structures requiring good corrosion-resistance applications, truck and marine, railroad cars, furniture, pipelines
6009 T4	A	A	A	C	A	A	A	A	B	Automobile body sheet
6010 T4	A	A	B	C	A	A	A	A	B	Automobile body sheet
6061 O	B	A	A	D	A	A	B	A	B	Heavy-duty structures requiring good corrosion resistance, truck and marine, railroad cars, furniture, pipelines
T4, T451, T4510, T4511	B	B	B	C	A	A	A	A	B	
T6, T651, T652, T6510, T6511	B	A	C	C	A	A	A	A	B	
6063 T1	A	A	B	D	A	A	A	A	B	Pipe railing, furniture, architectural extrusions
T4	A	A	B	D	A	A	A	A	B	
T5, T52	A	A	B	C	A	A	A	A	B	
T6	A	A	C	C	A	A	A	A	B	
T83, T831, T832	A	A	C	C	A	A	A	A	B	
6066 O	C	A	B	D	D	B	B	D		Forgings and extrusions for welded structures
T4, T4510, T4511	C	B	C	C	D	B	B	D	NA	
T6, T6510, T6511	C	B	C	B	D	B	B	D		
6070 T4, T4511	B	B	B	C	A	A	A	B	NA	Heavy-duty welded structures, pipelines
T6	B	B	C	C	A	A	A	B		
6101 T6, T63	A	A	C	C	A	A	A	A	NA	High-strength bus conductors
T61, T64	A	A	B	D	A	A	A	A		
6151 T6, T652	...	...	...	...	...	...	...	...	B	Moderate-strength, intricate forgings for machine and auto parts
6201 T81	A	A	...	C	A	A	A	A	NA	High-strength electric conductor wire
6262 T6, T651, T6510, T6511	B	A	C	B	A	A	A	A	NA	Screw-machine products
T9	B	A	D	B	A	A	A	A		
6351, T5, T6	B	A	C	C	A	A	A	A	B	Heavy-duty structures requiring good corrosion resistance, truck and tractor extrusions
6463 T1	A	A	B	D	A	A	A	A		Extruded architectural and trim sections
T5	A	A	B	C	A	A	A	A	NA	
T6	A	A	C	C	A	A	A	A		
7005 T53	B	B	C	A	B	B	B	B	B	Heavy-duty structures requiring good corrosion resistance, trucks, trailers, dump bodies
7049 T73, T7351, T7352	C	B	D	B	D	C	B	D	D	Aircraft and other structures
T76, T7651	C	B	D	B	D	C	B	D	D	
7050 T74, T7451, T7452	C	B	D	B	D	C	B	D	D	Aircraft and other structures
T76, T7651	C	B	D	B	D	C	B	D	D	
7072	A	A	A	D	A	A	A	A	A	Fin stock, cladding alloy
7075 O	...	...	...	D	D	C	B	D	D	Aircraft and other structures
T6, T651, T652, T6510, T6511	C(c)	C	D	B	D	C	B	D	D	
T73, T7351	C	B	D	B	D	C	B	D	D	
7175, T74, T7452	C	B	D	B	D	C	B	B	D	Aircraft and other structures, forgings
7178 O	...	...	...	...	D	C	B	D	D	Aircraft and other structures
T6, T651, T6510, T6511	C(c)	C	D	B	D	C	B	D	D	
7475 T6, T651	C	C	D	B	D	C	B	D	D	Aircraft and other structures
T73, T7351, T7352	C	B	D	B	D	C	B	D	D	
T76, T7651	C	B	D	B	D	C	B	D	D	

(a) Ratings A through E are relative ratings in decreasing order of merit, based on exposures to sodium chloride solution by intermittent spraying or immersion. Alloys with A and B ratings can be used in industrial and seacoast atmospheres without protection. Alloys with C, D, and E ratings generally should be protected at least on faying surfaces. (b) Stress-corrosion cracking ratings are based on service experience and on laboratory tests of specimens exposed to the 3.5% sodium chloride alternate immersion test. A = No known instance of failure in service or in laboratory tests. B = No known instance of failure in service; limited failures in laboratory tests of short transverse specimens. C = Service failures with sustained tension stress acting in short transverse direction relative to grain structure; limited failures in laboratory tests of long transverse specimens. D = Limited service failures with sustained longitudinal or long transverse stress. (c) In relatively thick sections the rating would be E. (d) This rating may be different for material held at elevated temperature for long periods. (e) Ratings A through D for workability (cold), and A through E for machinability, are relative ratings in decreasing order of merit. (f) Ratings A through D for weldability and brazeability are relative ratings defined as follows: A = Generally weldable by all commercial procedures and methods. B = Weldable with special techniques or for specific applications; requires preliminary trials or testing to develop welding procedure and weld performance. C = Limited weldability because of crack sensitivity or loss in resistance to corrosion and mechanical properties. D = No commonly used welding methods have been developed. (g) Ratings A through D and NA for solderability are relative ratings defined as follows: A = Excellent, B = Good, C = Fair, D = Poor, NA = Not applicable

used in airframe structures, mobile equipment, and other highly stressed parts.

Higher-strength 7xxx alloys exhibit reduced resistance to stress-corrosion cracking and are often used in a slightly overaged temper to provide better combinations of strength, corrosion resistance, and fracture toughness.

8xxx Series. Alloys in the 8xxx series encompass a wide range of compositions (see Table 2 in the article "Alloy and Temper Designation Systems" in this Volume). Wrought alloys containing lithium (2.4 to 2.8%) have been developed for use in aircraft and aerospace structures and cryogenic applications. Such alloys are described in the article "Aluminum-Lithium Alloys" in this Volume.

Types of Wrought Products

Commercial wrought aluminum products are divided basically into five major categories based on production methods as well as geometric configurations. These are:

- Flat-rolled products (sheet, plate, and foil)
- Rod, bar, and wire
- Tubular products
- Shapes
- Forgings

In the aluminum industry, rod, bar, wire, tubular products, and shapes are termed mill products, as they are in the steel industry, even though they often are produced by extrusion rather than by rolling. Aluminum forgings, although usually not considered mill products, are considered engineered wrought products.

In addition to production method and product configuration, wrought aluminum products also may be classified into heat-treatable and non-heat-treatable alloys. The initial strength of non-heat-treatable (1xxx, 3xxx, 4xxx, and 5xxx) alloys depends on the hardening effects of elements such as manganese, silicon, iron, and magnesium, singly or in various combinations. Because these alloys are work-hardenable, further strengthening is made possible by various degrees of cold working, denoted by

ATTACHMENT III - esp@cenet - Bibliographic data for JP 2000178704

WORKING METHOD FOR ALUMINUM ALLOY EXTRUDED SHAPE

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Inventor(s): TANIGAWA HISAO; OHORI KOICHI
Applicant(s): MITSUBISHI ALUMINIUM
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- international: *C22F1/00; C22C21/02; C22C21/06; C22F1/05; C22F1/00;* **C22F1/00; C22C21/02; C22C21/06; C22F1/05;** C22F1/00; (IPC1-7): C22F1/00; C22F1/05; C22C21/02
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Abstract of JP **2000178704 (A)**

PROBLEM TO BE SOLVED: To provide a working method for an Al alloy extruded shape, capable of manufacturing an Al alloy extruded shape excellent in bendability and energy absorption characteristic. SOLUTION: An Al alloy, having a composition consisting of, by weight, 0.6-1.2% Si, 0.5-1.0% Mg, 0.1-0.4% Fe, 0.2-0.6% Mn, 0.005-0.1% Ti, 0.05-0.3%; Cr and/or 0.05-0.25% Zr, and the balance Al with inevitable impurities, is extruded. The resultant Al alloy extruded shape is subjected to primary heat treatment under the aging condition T1 before the aging condition Th where the highest strength Hh of the Al alloy is reached. Then, bending is applied. Subsequently, secondary heat treatment is carried out under the aging condition T2 beyond the aging condition Th where the highest strength Hh of the Al alloy is reached.